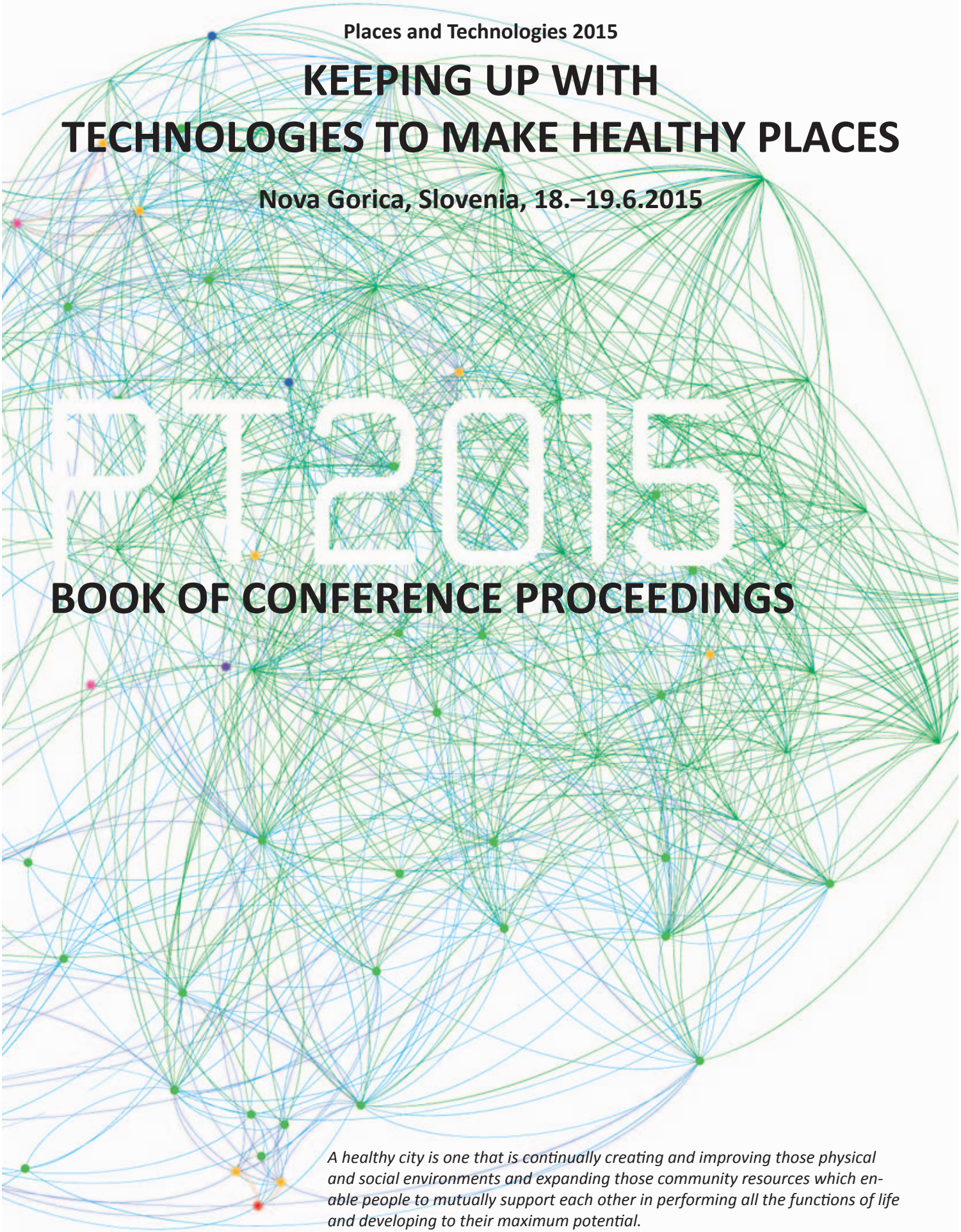
Places and Technologies 2015

# KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

**Nova Gorica, Slovenia, 18.–19.6.2015**




## BOOK OF CONFERENCE PROCEEDINGS

*A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential.*
*Health Promotion Glossary (1998)*

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# KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

BOOK OF CONFERENCE PROCEEDINGS

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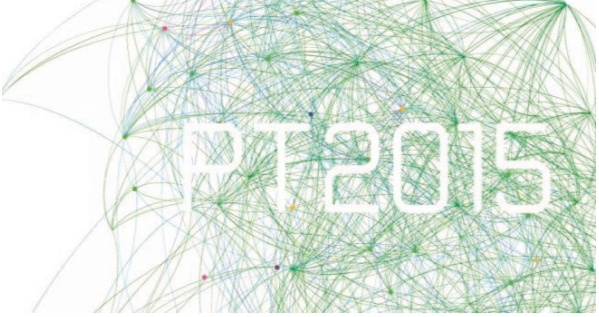
Nova Gorica, Slovenia

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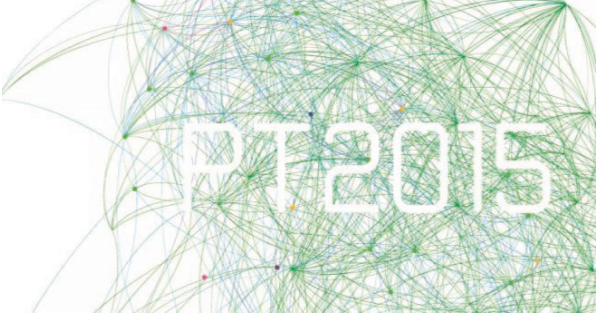

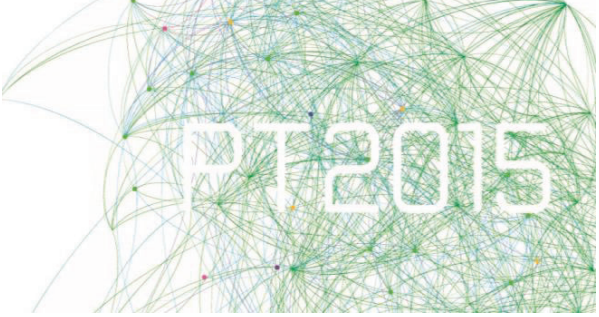

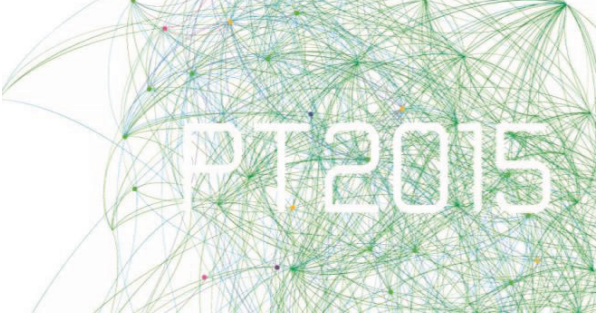

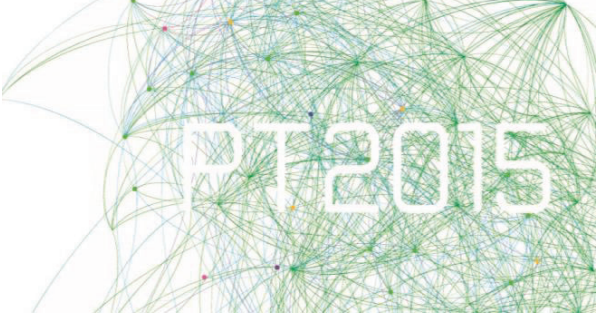

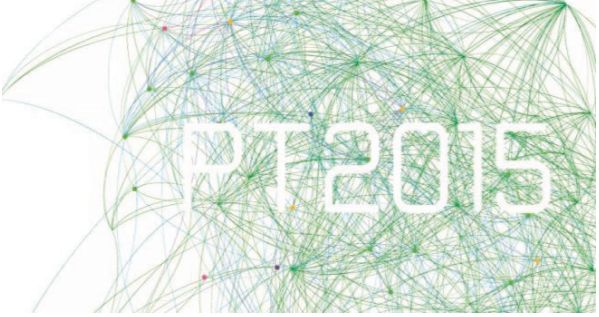

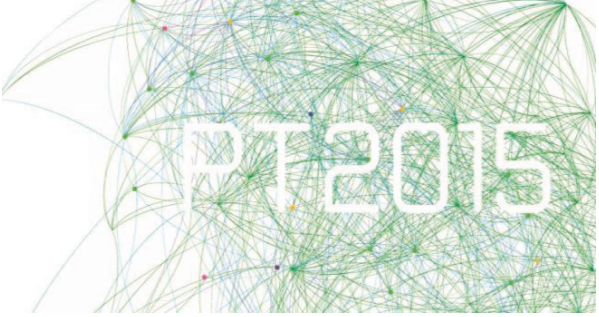

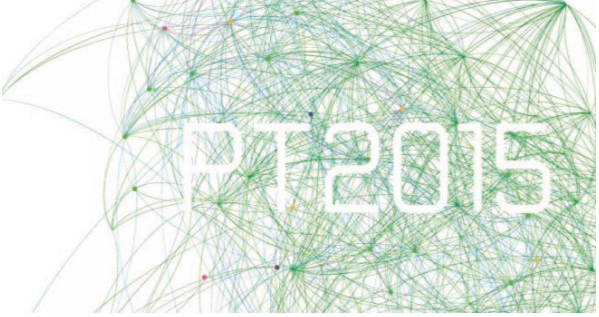

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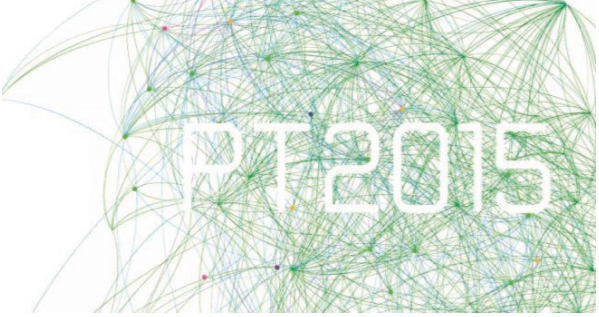


# FERROCEMENT ARCHITECTURAL STRUCTURES FROM THE ASPECT OF SOCIAL WELL-BEING

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## ABSTRACT

*The examples of use of ferrocement architectural structures are more numerous in recent years, with the aim to realize efficient and economically viable solutions. This paper analyzes the ferrocement architectural structures from the aspect of social well-being. The ferrocement structures are analyzed as subsystem of the building, whose behavior is directed towards the aim of system – building - ecological quality. The present analysis pointed to the advantages and disadvantages of ferrocement structures from the aspect of social well-being during the use phase of a building, that is, to the necessity of a complex and systemic approach to quality of building structures, in function of achieving the ecological quality of buildings.*

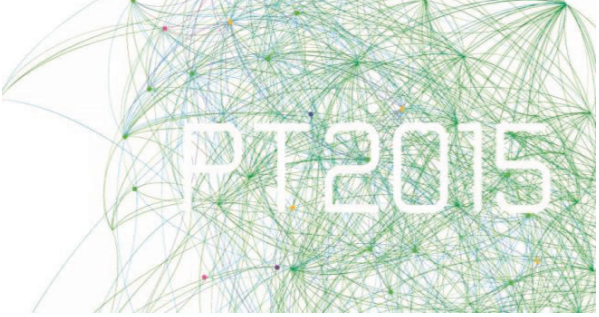
***Keywords****: sustainable building, ecological quality of buildings, ferrocement structures, social well-being.*

## INTRODUCTION

Raising the level of sustainability of building refers to the "reduction of negative environmental impact and resource consumption due to construction, use and dismantling of constructed facilities, with a simultaneous increase in life quality of and health and safety in the built environment"(Working Group for Sustainable Construction, 2001). In this process, it is important to assess the ecological quality of buildings (Nenadović, 2014), which includes quality assessment on the basis of indicators within the criteria of social well-being[1].

The building structure, along with other elements of architectural space, determines the performances of the building. The building structure should be designed and evaluated as a sub-system of the building, whose behavior is directed toward the aim of system-building, which within the criteria of social well-being refers to the realization of building performances that meet the needs and expectations of its users during the use phase of a building (Nenadović, 2014).

[1] The indicators for integrated assessment of ecological quality of building are classified by the interrelated and conditioned sustainability criteria into three groups: indicators within the environmental criteria, indicators within the criteria of social well-being, and indicators within the criteria of economic well-being (Nenadović, 2014).




There are numerous examples of applications of ferrocement architectural structures in recent times in the world, with the aim to realize efficient and economically viable solutions[2]. Ferrocement as a special form of thin-walled reinforced concrete[3], along with the economic viability, offers a wide range of functional and shaping possibilities. Compared to the conventional reinforced concrete, it is characterized by „enhanced elasticity, fine cracks, lower permeability to water vapor and gases, higher ductility and durability"(IFS Committees 10, 2001). Various structures and their elements can be built from ferrocement, including the elements of complex geometry, with the ability to build without formwork. Building the architectural structures in ferocement is not to demanding, from the technological point of view, neither it require special equipment.[4]

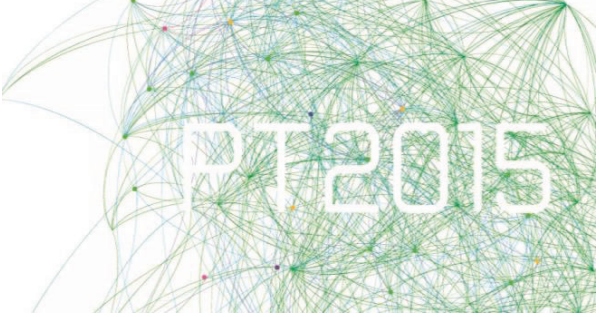
This paper analyzes the ferrocement architectural structures from the aspect of social well-being, on the basis of following indicators: protection and safety; aspects of comfort; electromagnetic field levels; quality of spatial organization; space adaptability; ease of building maintenance; visual aspects.

## FERROCEMENT ARCHITECTURAL STRUCTURES FROM THE ASPECT OF SOCIAL WELL-BEING

### Protection and safety

Ferrocement monolithic structures have proved as reliable and durable, when it comes to the safety of people during the natural disasters. The robustness of this type of construction is based on their continuity and ductility. The limiting factor in the application of this type of structures is limited possibility of precise numerical analysis of the load-bearing capacity for different loading cases, or the necessity of laboratory testing of physical models in order to perceive the behavior of the structure. Ferrocement is noncombustible material that has adequate fire resistance. However, during the fire action the degradation of mechanical properties of ferrocement elements can be observed. On average mechanical resistance to fire of ferrocement load bearing elements, that are not part of the composite assembly, is only 30 minutes, which represents a small fire resistance. Satisfactory values of mechanical resistance to fire can be achieved within the composite and sandwich structures.

[2] Since recently, ferrocement is applied in Serbia in a modest extent (Milinković, 2009). The first technical recommendation for ferrocement in Serbia was published by Federal institution for standardization in 2002.
[3] Ferrocement is made of a thin layer of cement mortar within which there is a high percentage of reinforcement, in form of multiple layers of continuous light network, which is made of closely spaced wires of relatively small diameter. The thickness of the elements is 1-3 cm, which is practically impossible in the case of classical reinforced concrete.
[4] Production of ferrocement elements is challenging in terms of expenditure of labor, which limits the application of this material in countries with high labour cost.




**Aspects of comfort**

Ferrocement surface elements, since they are very thin, have low thermal resistance, so it is necessary to incorporate additional layers of thermal insulation in the area of the building envelope. Monolithic ferrocement structures are favorable in terms of air sealing, minimizing the air leak. In order to ensure an adequate heat capacity and thermal inertia of the entire assembly, it is necessary to incorporate additional layers of materials with appropriate thermal characteristics. Ferrocement has a low permeability for water steam and gases and does not participate in the processes of humidity regulation. When it comes to the internal air quality, ferrocement can be considered as harmless material, practically with no emission of harmful gases, particles and microfibers. Due to the low air permeability of ferrocement, the possibility of air changes through the building envelope is reduced, which increases the risk for moistening the elements and mold growth. Single-layer ferrocement surface elements, given the small thickness, are characterized by high sound conductivity, i.e., a small insulating power. Studies have shown that the sound reduction index of ferrocement thin walls increases with the addition of stiffeners and that it further rises with addition of insulating filling[5]. When it comes to the impact sound insulation, ferrocement ceiling constructions imply additional floor layers, which reduce impact sound trans-mission. Satisfactory sound insulation properties must be ensured through the installation of floating floors which reduce vibration within ceiling element, in addition, through the installation of suspended ceilings, as well as through the adequate design of structural elements' connection details in order to avoid sound leakage, that is, the occurrence of sound bridges. Ferrocement structures and elements are suitable when it comes to the realization of assemblies in accordance with the desired acoustic qualities, since they can be freely shaped. The sound field phenomena: reverberation time, diffusivity and early reflections can be managed by designing the texture and shape of ferrocement elements.

**Electromagnetic field levels**

Ferrocement structural elements, especially those with a high percentage of reinforcement, can create unhealthy environment for users. Ferrocement surface elements can enhance the effect of electromagnetic radiation in the indoor environment, due to reflections and the superposition of electromagnetic waves.

[5] In the case of ferrocement partition made of two layers of ferrocement, between which there is a layer of air or porous absorbent material, the insulating power of partitions is better (for 2db and more) than in the case of solid wall of the same thickness („Award-winning Project: Treelodge@Punggol“, 2012).

## Quality of spatial organization

Ferrocement monolithic structures are suitable from the aspect of their adjustment to the form of space which is required by the social action (Figure 1). Structural elements can be shaped in such way that they occupy only the cross-sectional areas of social spaces, with the aim of creating "the most efficient structure for a given system of space" (Alexander, Ishikawa and Silverstein, 1977). The building structure can be optimized in accordance with the people and their needs (Kiesler, 1939).

**Figure 1: Javier Senosiain, The organic house, Naucalpan, Mexico, 1985. The preliminary sketch and the interior. http://www.arquitecturaorganica.com/casa-orgaacutenica.html**

## Space adaptability

By adequate shaping of ferrocement elements (beam elements of complex cross-section) or the whole structures (ribbed ferrocement shell) and by the formation of composite assemblies made of ferrocement and other construction materials (classical concrete and steel), a long span load bearing structures can be constructed, i.e., the higher net usable surface area can be achieved. This increases the possibility of space functioning for multi-purposes. In addition, important characteristic of ferrocement structures, when it comes to the space adaptability, is their durability and possibility of easy repair and maintenance, based on the application of readily available materials. But, in the case of space reconstruction, ferrocement elements can be limiting, because of the reduced potential for subsequent formation of openings within elements and because of difficulties in achieving the connection between new structural elements and existing structure. However, compared to the much thicker reinforced concrete elements, ferrocement elements can be considered favorable in terms of space adaptability.

## Ease of building maintenance

Ferrocement structures enable effective maintenance over the expected service life, with a minimum investment of human, material and financial resources, provided that they are designed in accordance with specific conditions in the macro and

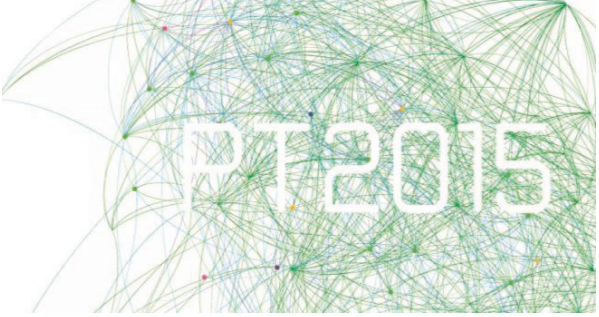
micro environment and properly built. Given the durability of ferrocement, i.e., taking into account that first ferrocement structures, built in mid-nineteenth century, are still in good condition (Pemberton, 1998), it is necessary to avoid the assemblies in which ferrocement is combined with less durable materials if the separation of individual materials is prevented.

### Visual aspects

The ferrocement, as a composite material whose structure, texture and colour are designed and thus the degree of reflection, as well as the ferrocement structures which allow a high degree of freedom in their shaping and in shaping of openings with the aim of light manipulation (Figure 1), can contribute the quality of light in the interior space, that is, affect the level of brightness, propagation of light and light intensity and colour. Ferrocement in its "natural" color ("non-color"), which is determined by the color of cement and aggregate whose base is gray, is assessed as "cold" from a lay person (Rutkin, 2005). On the other hand, if it is made in warm colors it can be perceived significantly different, primarily as "warm" (Benz and Rambow, 2008). Ferrocement structures can take "soft, non-aggressive forms, without sharp edges" that "cause pleasantness of touch and stimulate the subconscious to repeat the same experience" (Božović-Stamenović, 1997). Ferrocement, in the visual sense, can be experienced as a concrete with fine structure or as a rough mortar. In this context, in Europe ferrocement is associated with the mass usage of concrete or mortar within the buildings of different purposes, making it a "neutral" material, suitable for composing the spaces of different associative values. Ubiquity, standardicity, uniformity, availability, simplicity, steadiness, dynamism, freedom...ferrocement can "hide" many ideological backgrounds, i.e., take many meanings (Nenadović, 2014).

## CONCLUSIONS

The paper analysed the ferrocement architectural structures on the basis of indicators of social well-being for users during the use phase of the building. The ferrocement structures were analyzed as subsystem of the building, whose behavior is directed towards the aim of system – building - ecological quality. The analysis pointed to the advantages and disadvantages of ferrocement structures from the aspect of social well-being, that is, to the necessity of a complex and systemic approach to quality of building structures, in function of achieving the ecological quality of buildings. In this context, it is necessary to further develop the legal framework for planning and construction, as well as to further improve the education of designers, by including the complex and systemic assessment of impact of buildings and their subsystems, within the general framework for the assessment of ecological quality.

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